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Navy Case No. 83231

MATCHING FEED PARTIALLY INSIDE A WAVEGUIDE RIDGE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a ridge waveguide. More specifically, the present invention relates to a ridge waveguide resistive type feed with a matching transformer within the ridge of the waveguide which matches a standard coaxial transmission line to a ridge waveguide.

2. Description of the Prior Art.

Typically, in a simple transition feed for a waveguide the probe does not touch the upper surface and may require additional elements for impedance matching. One such probe design that extends partially into the waveguide is illustrated in U.S. Patent No. 5,867,073, to Sander Weinreb and Dean Bowyer which issued February 2, 1999. Disclosed in U.S. Patent No. 5,867,073 is a transition between a waveguide and a transmission line in which a probe portion of the transmission line extends into the waveguide to electrically field couple signals between the waveguide and transmission line. The transmission line is a coplaner fuse and includes a substrate having conductors disposed therein to prevent energy from propagating into the substrate from the waveguide. Since the

probe is formed as an integral element of the transmission line, direct coupling of the waveguide's signals to the transmission line occurs.

The probe heights of the type illustrated in U.S. Patent No. 5,867,073 and in other simple probe transition feeds are generally dimensionally sensitive and often impractical in ridge waveguides when the space from the top of the ridge to the top or upper face of the waveguide is relatively small.

Further, conventional probes are often shaped to successfully match the transmission line's impedance. Other prior well known art resistively matched transitions would require an external impedance matching network when the waveguide impedance differs from the coaxial transmission line impedance.

Accordingly there is a need for a relatively compact, simple in design yet highly effective feed which does not require substantial probe shaping and/or an external matching network to impedance match the waveguide to a coaxial transmission line.

SUMMARY OF THE INVENTION

The impedance matching feed comprising the present invention overcomes some of the difficulties of the past

including those mentioned above in that it is a relatively simple in design, yet highly effective for matching the input transmission line impedance, which is generally fifty ohms, to the waveguide impedance. The impedance of the ridge waveguide is an arbitrary impedance, that is it will generally be different than the impedance of the coaxial transmission line.

The impedance matching feed consist of a matching transformer located within the ridge of the waveguide. The feed matches a standard coaxial transmission line, which is generally fifty ohms, and does not require an external matching network. A probe extends, from the transformer, vertically upward within the waveguide's interior to the upper wall of the waveguide and is electrically connected to the waveguide. One end of the waveguide is terminated in a quarter wave choke, which is a short approximating $\lambda_g/4$.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross sectional view of an impedance matching feed partially located in a ridge waveguide comprising one embodiment of the present invention;

Figs. 2a and 2b are electrical equivalent circuit diagrams for the impedance matching feed of FIG. 1;

Fig. 3 is a cross sectional view of an impedance matching

feed comprising a second embodiment of the invention which has a tapered transformer; and

Fig. 4 is a cross sectional view of an impedance matching feed comprising a third embodiment of the invention which has a stepped transformer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to Fig. 1, there is shown a probe 10 which couples a coaxial transmission line 14, which is generally a connector, to a hollow metallic waveguide 16. As depicted in Fig. 1, coaxial transmission line 14 is mounted on the bottom surface of waveguide 16. The waveguide 16 may also be a dielectric filled metallic waveguide.

The waveguide 16 is formed of a hollow interior 18 with open ends to receive and deliver radio frequency signals. Waveguide 16, which has a rectangular shape, includes an upper or top wall 20, a lower or bottom wall 22 and a pair of side walls 24 and 26. A ridge 28, which is located at or near the center of the waveguide 16, runs the length of waveguide 16, and extends vertically upward from bottom or lower wall 22 of the waveguide 16. One end of the waveguide 16 is terminated with a quarterwave choke, which is a short approximately $\lambda_g/4$.

A transformer 30 located within ridge 28 electrically

connects the probe 10 to the coaxial transmission line 14. Coaxial transmission line 14 typically has an impedance of fifty ohms. Coaxial transmission line 14 includes an inner conductor 32 which may be any electrically conductive material, a dielectric 34 which may be any well known dielectric material, and an outer conductor 35.

As shown in Fig. 1, the transformer 30 consist of a circular inner conductor 36 and a dielectric 38 which surrounds the conductor 36 and is shielded by the metallic ridge 28. Probe 10 is a conductor which extends vertically upward from ridge 28 to the upper wall 20 of waveguide 16. The upper end of probe 10 is electrically connected to the bottom surface 40 of upper wall 20. The conductor 36 of transformer 30 and probe 10 may be fabricated from any well known electrical conductor. Probe 10 couples radio frequency electrical signals between the waveguide 16 and the transmission line 14.

Transformer 30 is shown in Fig. 1 as being positioned above reference plane 42-42. The coaxial transmission line 14 is connected to waveguide 16 below reference plane 42 as shown in Fig. 1. The diameter of transformer 30 is configured to provide an impedance match with the coaxial transmission line 14 at reference plane 42-42.

Referring now to Figs. 1, 2a and 2b, an electrical

equivalent circuit for the feed to the waveguide is depicted in Figs. 2a and 2b. In Figs. 2a and 2b, L_1 is the length for the shorted end of waveguide 16 and L_2 is the length for transformer 30. Z_{44-44} is the impedance looking into transformer 30 when transformer 30 is terminated with the characteristic impedance for the coaxial transmission line 14. Z_g is the waveguide impedance. Z_{coax} is the impedance of coaxial transmission line 14 which is normally fifty ohms but Z_{coax} may have another value. $Z_t(L_2)$ is the impedance of the transformer 30 which can be variable as a function of transformer length, or $Z_t(L_2)$ can be a constant impedance.

To obtain an impedance match with coaxial transmission line 14 at reference plane 42-42, the reactances must be tuned out. The diameter of probe 10 may be shaped to tune reactances to a desired level, when needed. Shunt susceptance is made zero by terminating the waveguide with a quarterwave choke. A match occurs when Z_{44-44} is the same as the waveguide impedance Z_g. Since Z_{44-44} is the impedance looking into transformer 30, the impedance profile $Z_t(L_2)$ can be selected to make Z_{44-44} match the waveguide impedance Z_g.

Thus, the coaxial feed impedance, which is normally fifty ohms, does not have to be the same as the waveguide impedance to obtain a match between the waveguide 16 and the coaxial

transmission line 14.

For the relatively simple case of a single step quarter wave transformer, the impedance $Z_t(L_2)$ is kept constant and the length L_2 is selected to be $\lambda/4$ at the operating frequency. The impedance looking toward the short is:

$$Z_s = jZ_g \tan BL_1 \qquad (1)$$

which is an open circuit and the input impedance for the equivalent circuit of Fig. 2a becomes:

$$Z_{in} = -jX_c + jX_1 + Z_{44\text{-}44} \qquad (2)$$

When probe 10 is shaped such that the reactances cancel, an impedance match is obtained when $Z_{44\text{-}44}$ equals Z_g. For the single step quarter wave transformer, $Z_t(L_2)$ is found from the following equation:

$$Z_t(L_2) = \sqrt{Z_g(Z_{coax})} \qquad (3)$$

which is constant as a function of length L_2.

The matching feed of Fig. 1 works well even when the waveguide impedance is substantially different than the coaxial input impedance due to the transformer contained within the ridge of waveguide 16. The matching feed of Fig. 1 also works well when the space between the top of the waveguide's ridge and the top of the waveguide is relatively short, i.e. substantially less than $\lambda/4$.

Referring to Figs. 3 and 4, Fig. 3 depicts a tapered transformer 50 which has a tapered conductor 52 and a dielectric 54 with an outer diameter which is uniform. Fig. 4 depicts a transformer 60 which has a stepped conductor 62 and a dielectric 64 which has a uniform outer diameter. The transformer 60 of Fig. 4 has a plurality of steps 66, 68 and 70 with each step 66, 68 and 70 having a different diameter. The lengths of each step 66, 68 and 70 of transformer 60 are usually equal as shown in FIG. 4.

The impedance of the transformers 50 and 60 is $Z_t(L_2)$ which may vary along the length of the transformers 50 and 60. It should be understood that the outer diameters of transformers 50 and 60 can also be made variable stepped or nonuniform with their respective conductors 52 and 62 being constant or variable stepped or nonuniform.

For the stepped version, the number of steps is arbitrary and can be different than the three steps as shown in FIG. 4. Probe and transformer diameters may also be non-circular

While FIGS. 3 and 4, show the outer dielectric diameters of the transformer being constant and the inner conductor diameters varying, the inner conductor and the outer dielectric or both may be varied in any manner to obtain the impedance profile needed for the transformer. The impedance matching

feed may be used with single and double ridge waveguides, or other waveguide geometries, such as waveguides which are asymmetric. The probe diameter may also be shaped and can have a dielectric material around it. The probe diameter may be different than the diameter of the transformer's inner conductor and it may be shaped such that its radius varies as a funtion of length.

From the foregoing, it is readily apparent that the present invention comprises a new, unique and exceedingly useful and effective impedance matching feed partially located in a waveguide ridge which constitutes a considerable improvement over the known prior art. Many modifications and variations of the invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims that the invention may be practiced otherwise than as specifically described.